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THE EFFECTS OF AUGMENTING FACE-TO-FACE MEETINGS WITH WEB-BASED ASYNCHRONOUS GROUP SUPPORT SYSTEMS

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ABSTRACT

Most group support systems (GSS) laboratory studies compare face-to-face groups with groups assigned to either a synchronous or asynchronous decision support system. Research findings have been inconclusive. Results of a laboratory study of groups that worked on a selection problem are presented. One set of groups shared information using an asynchronous Web-based system before meeting in a face-to-face setting to discuss and make a decision. The other set of groups met, shared information, discussed the problem, and made a decision in a face-to-face meeting exclusively. Groups that shared information using a Web-based asynchronous system and discussed the shared information in a face-to-face meeting environment assembled more information and made higher quality decisions in less time than groups that shared and discussed information in a face-to-face meeting environment.

INTRODUCTION

Most important decisions in organizations are made by groups or by an individual with the advice of a group (Mintzburg 1983). However, it has been long established that groups can be ineffective decision makers because of group process losses that can outweigh group process gains (Maier 1967). Over the years research has been conducted aimed at finding ways of making groups more productive. Solutions have ranged from manual group process structuring techniques such as the Delphi method (Dalkey 1969) and the Nominal group technique (NGT) (Delbecq, Van de Ven, and Gustafson 1975) to contemporary group support systems (GSS) (DeSanctis and Gallupe 1987). Decision support systems were intensively studied during the last decade of

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the twentieth century. A meta-analysis of laboratory studies by Fjermestad and Hiltz (1998-99) included two hundred and thirty studies that had been reported in academic journals and conferences by August 1998. Researchers have noted with concern that research results have been inconclusive. Research has not been able to conclusively establish superiority of GSS over the traditional face-to-face meeting (Kiesler and Sproull 1992). A meta-analysis of laboratory studies that compared the performance of groups assigned to GSS with groups assigned to the traditional face-to-face meeting found only 16.3% of all hypotheses investigated had outcomes favorable to GSS groups (Fjermestad and Hiltz, 1998-99). Possible reasons for this are varied and include; poor experimental designs and subjects used in laboratory experiments.

There are two major problems with subjects used in reported experiments. First, most of the experiments have used students. Student subjects are problematic in the sense that there is always a question of how motivated they are when participating in these experiments even in cases where some form of incentive is offered. Second, there is the issue of ad hoc versus established groups. Student subjects are mostly ad hoc groups assembled for the experiment only and hence lack the motivation and social cohesion to work as a unit. Experiments using professional subjects have not produced consistent results either. Some laboratory experimental studies that used professionals as subjects (Adrianson and Hjelmquist 1991; Hiltz, Johnson, and Turoff 1986), show higher dominance, more consensus and a higher degree of information exchange in face-to-face groups than in GSS groups. Other laboratory studies that also used professional subjects show GSS groups performing better than face-to-face groups (Lam 1997).

As Fjermestad and Hiltz (1998-99) point out, most laboratory experiments have used either groups that are too small, that is, groups of four or less participants, or too few groups to produce meaningful generalizable results. In most cases, groups are made small to boost the number of groups. Another design problem is the nature of tasks. Tasks that are too simple may not enable the unveiling of the effects of a GSS on the group process. A consistent design feature in reported laboratory studies is the comparison of face-to-face groups with groups using either a synchronous or asynchronous group support system. Kiesler and Sproull (1992) contend, "The standard of comparison is face-to-face meetings, not because they are always preferable to other forums but because they are ubiquitous." Other possible reasons include the fact that face-to-face meetings are easier to set up and data can be collected and analyzed quickly. Early GSS systems were also designed for the meeting room environment. Very few experiments have focused on using a mixture of decision support systems to support the group decision-making

CONTRIBUTION

This paper makes a contribution to IS research in that it shows positive effects of augmenting face-to-face meetings. The research findings reported in this paper may explain the inconsistent findings of experiments that have compared GSS supported groups with groups meeting in face-to-face meeting environments.

We present the results of a laboratory experiment that compared the performance of groups that met and deliberated on a selection problem in a face-to-face meeting exclusively, with groups that first shared information using a Web-based asynchronous GSS and then discussed in a face-to-face meeting. Results show that augmenting face-to-face meetings with the asynchronous GSS improved the group decision-making process.

This research is expected to be very interesting to IS researchers and managers who may want to explore the value of providing teams with a structured Web-based asynchronous information sharing system in preparation for face-to-face meetings. Preliminary results of this research show that such teams would share more information and make high quality decisions faster than they would in just face-to-face meetings. The paper is also expected to be of interest to IS researchers who may want to explore different mixtures of group tasks and group support systems.

process (Ocker, Fjermestad, Hiltz, and Johnson 1998).

This research explores the effect of splitting the group decision-making process and using different support systems to support each phase. We develop and test a methodology for configuring support for decision-making groups. The methodology considers three distinct aspects of the group decision-making process: the group task, structuring the decision-making process, and using information technology to support the process. Bales (1950) suggests that a group decision-making task should be guided by three main questions; "What are the facts?", "How should the facts be organized and analyzed?", and "What conclusions are justified from an examination of the facts?" The nominal group technique (Delbecq, Van de Ven, and Gustafson 1975) is one way of structuring a group decision-making process. The three guiding questions are matched to four steps of the NGT supported with an appropriate type of group support system (GSS). Three types of support systems are considered: asynchronous GSS, synchronous GSS used to augment a face-to-face meeting, and face-to-face meeting with no technological support.

The next section presents a pictorial view of the group support configuration methodology, the rationale for assigning each of three group task questions to a particular step of the NGT, and the choice of GSS to support each of the four NGT steps. A laboratory experiment conducted to test the methodology is then presented followed by a discussion of the results. Results, implications, and suggestions for future related research conclude the paper.

CONFIGURING SUPPORT FOR DECISION-MAKING GROUPS

Decision-making groups can utilize a variety of tools and techniques to help them make better decisions. The nominal group technique (Delbecq, Van de Ven, and Gustafson 1975) is one method that can be used to provide structure to the group decision making process. Bales (1950) provides three basic questions decision-making groups should use to break the group task into clearly defined sub-tasks. Different types of information systems have been designed to support group decision making. Figure 1 shows a methodology that can be employed to configure support for a decision-making group.

The nominal group technique (NGT) consists of four main steps: silent idea generation, round robin recording of ideas, preliminary voting on items of importance and discussion, and final group decision making or voting. The first two activities; silent idea generation and round robin recording of ideas, mirror Bales' first question, "What are the facts?" The second question, "How should the facts be organized?" matches the third step of NGT, preliminary voting on items of importance and group discussion. The third question "What conclusions are justified from an examination of the facts?" matches the last step of NGT, final vote or group decision.

Group support systems and process structuring techniques are designed to eliminate or minimize group process losses and/or promote group process gains (Nunamaker, Dennis, Valacich, Vogel, and George 1991). However, when used inappropriately, information technology tools can be a source of group process losses (Dennis 1996; McLeod, Baron, Marti, and Yoon 1997). Support for each of the three questions posed above to guide group decision making should be tailored to reduce or avoid group process losses and/or increase group process gains. When a single system is used to support the group decision-making process, it is possible that the system may introduce group process gains for one of Bales' three guiding questions and group process losses for another. Such a situation could be a possible explanation for the inconsistent findings reported in experimental GSS studies.

In a manual NGT session, the meeting facilitator/leader asks participants to generate ideas on the discussion topic silently and independently. Although the designers of the technique believed that adequate time could be allocated in a meeting setting for thinking and reflection, in reality this may not be the case. Time for idea generation can be too short for some participants. There can be added social pressure if some leaders perceive that they

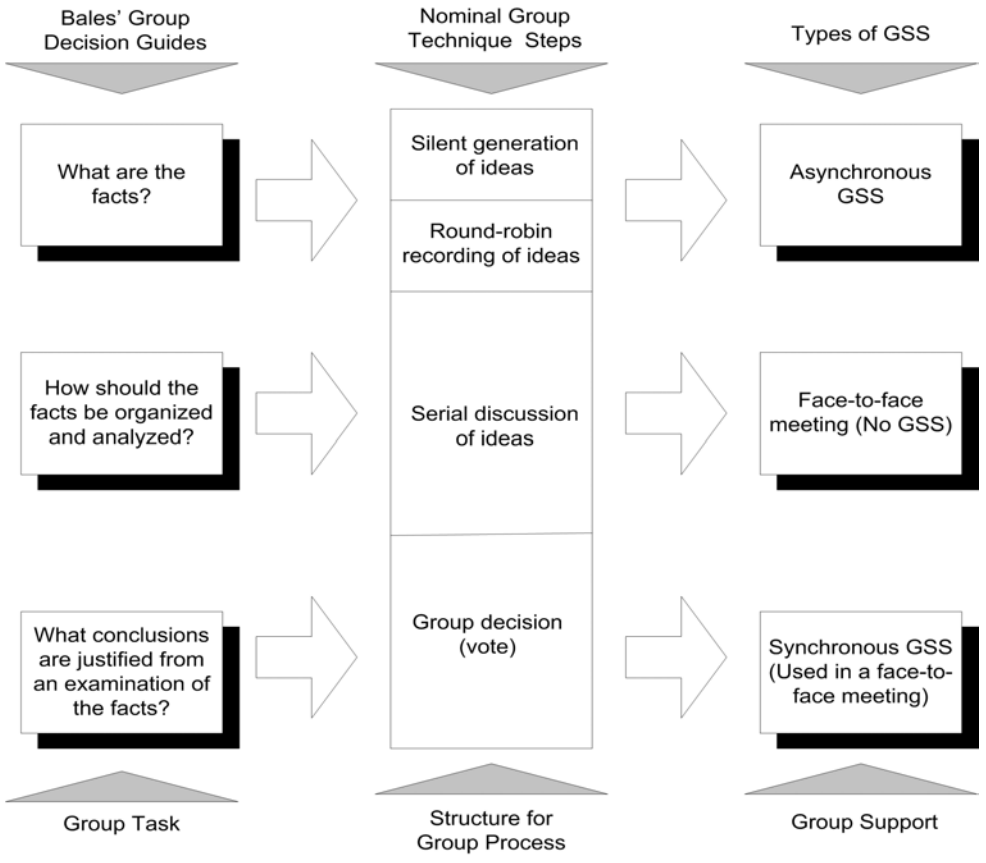

Figure 1. A methodology for configuring support for a decision-making group

need to come up with better ideas because of their status in the organization. The round robin recording of ideas that follows the generation of ideas can be another source of group process losses. Some participants may not contribute because of fear of social retribution. When the technique was conceived it was believed that several rounds of recording ideas and the resultant long list of ideas would make participants forget who contributed what fact (Delbecq, Van de Ven, and Gustafson 1975). While in some cases this might be true, the assumption that a long list of ideas will always be generated or that people will forget idea contributors cannot always be expected to hold. Besides, the author of an idea may always think other participants know who contributed the idea.

Most GSS are built with an anonymity feature implemented through either no author identification at all or the use of pen names. A laboratory experiment by Jessup and Tansik (1991) found that groups working anonymously and apart generated more ideas than identified groups working in the same room. Synchronous GSS do not eliminate group process losses caused by time pressure. Participants are still expected to enter facts and share them with the group during the limited meeting session. Another feature of GSS, parallel communication, which is designed to prevent attention and production blocking, can also introduce group process losses. Participants may post duplicate facts, worded differently, to the group information pool because of lack of time to analyze what others are posting. While parallel communication prevents participants from being unduly influenced by what others are saying, it can result in unnecessary information overload. An asynchronous GSS can offer all the benefits offered by synchronous GSS without the group process losses caused by time pressure. In particular, participants have more time to reflect on other participants' contributions, so

the probability of duplicate entries and the attendant unnecessary information overload is greatly diminished. Participants with poor keyboard skills, for instance senior executives or users in less developed countries (De Vreede, Jones, and Mgaya 1998-1999), are also not inhibited as is the case in a synchronous GSS setting. We therefore propose an asynchronous GSS to support the question "What are the facts?" or the first two steps of the nominal group technique.

Step three of the NGT, serial discussion of ideas, requires participants to convince their colleagues of the strengths or weaknesses of each of the facts generated and ranked in the earlier steps. At this stage, it is advantageous for group members to take turns speaking. Parallel communication of GSS, which is meant to minimize production and attention blocking, is not helpful because the facts to be debated are already known at this point. Depending on the type of task, anonymity may not be an issue either. Only in a situation where a group consists of bosses and subordinates would being identified with a particular side of a debate be an issue. The lack of aural and visual cues in electronic communication makes it less effective for emphasizing points, compared to verbal communication. Therefore, a face-to-face meeting may be the most ideal for the discussion phase or answering the question, "How should the facts be organized and analyzed?"

By taking a vote or having each group member rank the alternatives under consideration, the group can reach a consensus or make a final decision. In a manual (face-to-face) NGT process, this step can introduce domination, fear of nonconformance with the group, and free riding group process losses. Research has shown that choice shift is higher for groups under identified face-to-face conditions than for GSS anonymous groups (Adrianson and Hjelmquist 1991). The higher choice shift is evidence of group members shifting to conform to the rest of the group or "groupthink" as the phenomenon is often called. Anonymity is the key feature that makes use of a GSS, whether synchronous or asynchronous, ideal for the final decision-making step. However, a face-to-face meeting supported by a synchronous GSS has the advantage of enabling the group to iterate between verbal discussion and voting using the GSS until a consensus is reached. We therefore suggest a face-to-face meeting augmented with a synchronous GSS to answer the last Bales question, "What conclusions are justified from an evaluation of the facts?"

METHODOLOGY EVALUATION

The hidden profile problem (Stasser and Titus 1985) is a group task that enables the development of quantifiable measurements for both group process efficiency and effectiveness. "Hidden profile" refers to a selection problem where a group as a whole is given all the information to find a best alternative, but individual members of the group are given information favoring alternatives other than the best. Ideally, effective sharing and synthesis of information should lead members away from their initial biases towards the best alternative. In face-to-face meetings, research suggests selective discussion and weighting as major reasons for group failure to solve the hidden profile problem. Information that is shared by more people has a higher probability of being brought up for discussion than information that is only known by a minority of the group members (Gigone and Hastie 1993). Also, group members tend to bring up for discussion information that reinforces preferences that are held prior to the meeting, and suppress information that contradicts those preferences (Stasser and Stewart 1992).

Group support effectiveness and efficiency can be measured by the extent to which a group is enabled to share unique and partial information and solve the hidden profile problem. Groups that share most unique and partially shared information are expected to uncover the hidden profile in less time than groups that fail to share unique and partially shared information effectively. To test the mixed group support methodology, a Web-based information sharing system was designed and used as the asynchronous GSS to support the first steps of the NGT, or the first Bales question "What are the facts?" The system was written in Java. Below are brief descriptions of two of the main applets.

Figure 2 shows the idea generation applet user interface. After selecting a candidate and an evaluation criterion, all the facts that the user would have entered for that candidate/criterion combination are displayed in a scroll down window in the middle of the screen. At the bottom of the screen is the text input box where users typed new facts.

From the starting page users could link to the information sharing applet (Figure 3). This applet enabled users to compare their entries with group entries and send or get entries to/from the group pool. As a result, the group information pool contained only unique facts collectively known by all group members. Importing facts from the group pool enabled members to have the same information in their private pools as in the group pool, if they wished. If a user did not have entries in the private information pool, group information was blocked, thus preventing importation of group facts. The meeting facilitator controlled the minimum number of facts that had to be in an individual's information pool for sharing with the group to be enabled.

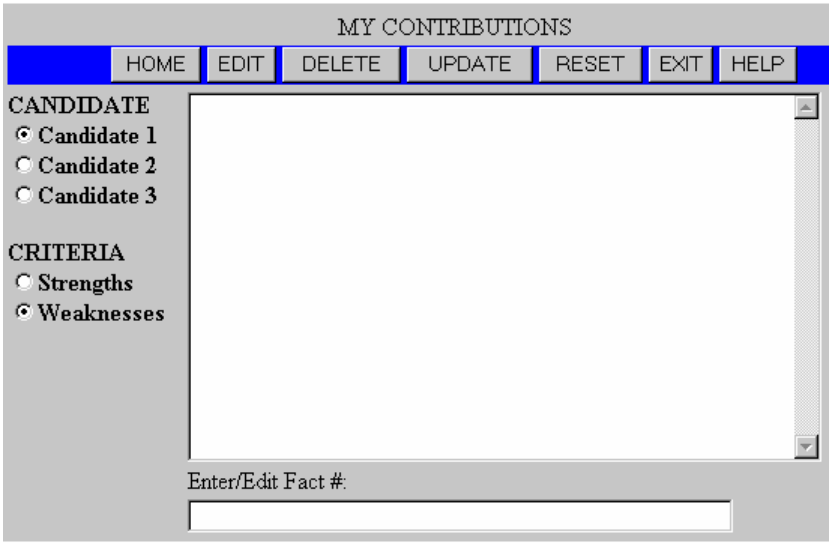

Figure 2. Idea Generation Applet User Interface

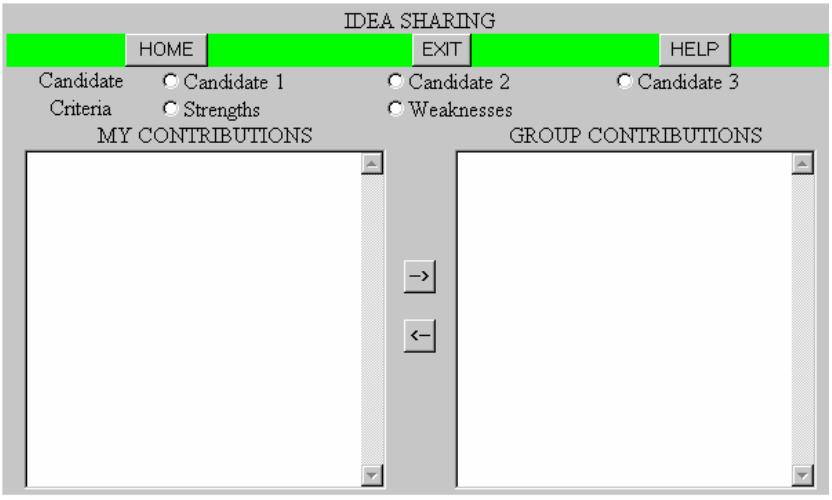

Figure 3. Group Information Sharing Applet User Interface.

LABORATORY EXPERIMENT

Task

The experimental task was an evaluation of three candidates for a group product manager position at a fictitious company. The task was an adaptation of a management game (Burst and Schlesinger 1987). Participants evaluated the candidates based on the job description for the group product manager position, the company's hiring policy, and the evaluation comments about each candidate made by the president of the hiring division.

Laboratory Experiment Design

The experiment was a 2 X 2 factorial design crossing two levels of support environment with two levels of information distribution. The two levels of support environment were: (1) a mixed group support environment where groups used a Web-based asynchronous system to share information and discussed the facts in a face-to-face meeting and (2) a face-to-face meeting environment for information sharing, discussing and decision-making. Information distribution levels were: same and partial-biased information distribution. In the same information distribution treatment all three members of a group had the same full set of information. In the biased information distribution groups information was distributed such that two of the group members had information favoring one candidate and the other had information favoring another candidate. The two candidates favored by group members in this treatment were the two that were not the best, according to evaluations by human resources experts. Burst and Schlesinger (1987) provide expert evaluation scores of each candidate. The full set of information consisted of 33 comments made by the division president when he evaluated the three candidates based on their resumes, work histories, and personality reports. The information distribution factor, therefore, created a hidden profile (Stasser and Titus 1985). The treatment cells were coded as shown in Table 1.

Subjects

One hundred and forty-four undergraduate students at a large, southwestern US university were used as participants for this research. Twelve groups of three students were assigned to each of the four treatment cells resulting from the design described above. In other studies in this stream of research that have used students as experimental units, researchers offered incentives to encourage serious participation that would ensure meaningful research findings. To encourage meaningful participation, the participants were awarded extra course credit for participating. In addition, there was a $60.00 cash prize for the group producing the best ranking of the three candidates in each of the four treatment cells.

Table 1. Experiment treatment cells.

Treatment Cell	Support Environment	Information Distribution
A	Face-to-face meeting only, no use of a group support system	Biased information distribution. Each group member is given information that is biased towards a particular candidate
B	Face-to-face meeting only, no use of a group support system	Same information. All group members are given the same information for all candidates
C	Face-to-face meeting for discussion and an asynchronous GSS for sharing information prior to the face-to-face meeting	Biased information distribution. Each group member is given information that is biased towards a particular candidate
D	Face-to-face meeting for discussion and an asynchronous GSS for sharing information prior to the face-to-face meeting	Same information. All group members are given the same information for all candidates

Experimental Procedures

Mixed Support Treatment

A week before the meeting date, participants were given an information package which included a cover sheet, a case description, and evaluation sheets. The cover sheet introduced the experimental task and provided a Web site and a unique password for the system. The password was designed to identify the group to which the recipient belonged, but this information was not

revealed to the participants. The identity of group members was revealed on the day participants met to discuss the case. The information packages were randomly distributed to the students, thereby randomly allocating them to groups. A demonstration was run to show participants how to use the system. Participants had a week to share information. On the meeting day, they were given reports showing the information they had gathered using the Web-based system and were assigned to decision rooms. In the decision rooms, they were seated so that they could not see each others' information sheets and were asked not to let their team members see their sheets. They were instructed to start discussing a ranking of three candidates based on the information in their reports. After discussion, they recorded the group's consensus ranking and the time it took them to reach that consensus. Groups were given up to 50 minutes for the discussion phase. They were instructed to stop and record the discussion time as soon as they reached a consensus on the ranking of the three candidates.

Face-to-face Treatment:

The face-to-face groups were also given the case study a week before the scheduled meeting date. However, they were admonished not to share information during the preparation period, nor were they told who was in their groups. On the meeting day, the groups to which they would belong were revealed and they were seated so that they could not see each others' information sheets.

The groups followed the four steps of the NGT to decide how to rank the three candidates. First they silently listed each candidate's strengths and weaknesses (10 minutes were allocated for this first step). The second step was to share information. Participants took turns in a round robin manner to write on a flip chart visible to the whole group. Up 20 minutes were allocated for this step. Participants were asked to add to their information sheets any information recorded by the group on the flip chart that they did not have and thought was important in deciding whom to hire. The last two steps were to discuss and come to a consensus ranking of the three candidates. Up to 50 minutes were allocated for the last two steps giving a possible 80 minutes for the whole decision-making process. Groups were instructed to stop and record the discussion time as soon as they reached a consensus on the ranking of the three candidates.

Dependent Variables

The dependent variables at the group level were discussion time taken by the group to reach a consensus on the ranking of the three candidates, and quality of the group's decision (i.e., ranking of the candidates). Discussion time for face-to-face groups excluded the time taken to share information. Another dependent variable at the group level was the size of the group's information base, operationalized as the number of unique comments in the group's information space. For face-to-face meeting treatment groups, this was a physical count of facts (comments) listed on the group's flip chart, and for Web-system groups, this was a count of facts in the group's database table. Group decision quality was operationalized by allocating points to each of the six possible ranking combinations of the three candidates as shown in Table 2.

Experiment Hypotheses

Groups that first shared information using the Web-based information sharing system before discussing and making a decision in a face-to-face meeting had more time to share and reflect on the shared information. In particular, time and use of a Web-based information sharing system were expected to enable groups in the biased information distribution treatment cell to overcome the information discrepancy among group members. Groups in the same information distribution treatment were considered control groups that were expected to easily assemble all the 33 information pieces given to each group member. In terms of the size of group information pools after sharing, it was hypothesized that,

Hypothesis 1: Groups in the GSS augmented face-to-face meeting environment and biased information distribution treatment cell will assemble the same number of facts as groups assigned to the same information treatment cells.

Table 2. Candidates Ranking Scoring Guide

Candidate Rankings			
First	**Second**	**Third**	**Points**
Candidate 3	Candidate 1	Candidate 2	6
Candidate 3	Candidate 2	Candidate 1	5
Candidate 1	Candidate 3	Candidate 2	4
Candidate 1	Candidate 2	Candidate 3	3
Candidate 2	Candidate 3	Candidate 1	2
Candidate 2	Candidate 1	Candidate 3	1

$$1a \quad \begin{matrix} H_0 : \mu_C = \mu_B \\ H_a : \mu_C \neq \mu_B \end{matrix} \quad \text{and} \quad 1b \quad \begin{matrix} H_0 : \mu_C = \mu_D \\ H_a : \mu_C \neq \mu_D \end{matrix}$$

Where

μ_B = Mean of the number of facts assembled by groups in the face-to-face exclusively meeting environment and same information distribution treatment cell.

μ_C = Mean of the number of facts assembled by groups in the GSS augmented face-to-face meeting environment and biased information distribution treatment cell.

μ_D = Mean of the number of facts assembled by groups in the GSS augmented face-to-face meeting environment and same information distribution treatment cell.

The Web-based group information system was expected to enable groups to share as much information as possible. It was therefore expected that the group assigned to the system would pool more information than groups that shared information in a face-to-face meeting environment. Therefore,

Hypothesis 2: Groups in the GSS augmented face-to-face meeting environment and biased information distribution cell will assemble more facts than counterpart groups in the face-to-face meeting exclusively and biased information distribution cell.

$$2: \quad \begin{matrix} H_0 : \mu_A - \mu_C = 0 \\ H_a : \mu_A - \mu_C < 0 \end{matrix}$$

Where

μ_A = Mean of the number of facts assembled by groups in the face-to-face exclusively meeting environment and biased information distribution treatment cell.

μ_C = Mean of the number of facts assembled by groups in the GSS augmented face-to-face meeting environment and biased information distribution treatment cell.

Groups in the GSS augmented face-to-face meeting environment treatment cells had more time to share and reflect on shared information. Unlike the groups in Dennis (1996) who were able to share more information but not use it productively, groups in the biased information distribution cell were expected to share and assimilate most of the information. They were,

therefore, expected to take less time to reach a consensus as well as uncover the hidden profile. Therefore;

Hypothesis 3: Groups in the GSS augmented face-to-face meeting environment treatment cells will take less time to reach a consensus than groups in the face-to-face meeting exclusively treatment cells.

$$3a: \begin{array}{lllllll} H_0 & : & \mu_A & - & \mu_C & = & 0 \\ H_a & : & \mu_A & - & \mu_C & > & 0 \end{array} \qquad 3b: \begin{array}{lllllll} H_0 & : & \mu_B & - & \mu_D & = & 0 \\ H_a & : & \mu_B & - & \mu_D & > & 0 \end{array}$$

Where

μ_A = Mean time taken to reach a decision by groups in the face-to-face exclusively meeting environment and biased information distribution treatment cell.

μ_B = Mean time taken to reach a decision by groups in the face-to-face exclusively meeting environment and same information distribution treatment cell.

μ_C = Mean time taken to reach a decision by groups in the GSS augmented face-to-face meeting environment and biased information distribution treatment cell.

μ_D = Mean time taken to reach a decision by groups in the GSS augmented face-to-face meeting environment and same information distribution treatment cell

To solve the hidden profile problem groups need to share and effectively use the shared information (Dennis 1996). Groups in the same information distribution cells did not have a hidden profile problem; they were therefore expected to make high quality decisions. Since groups that used the Web-based information sharing system were expected to share and assimilate more information, groups in GSS augmented face-to-face meeting environment and biased information distribution treatment cell were expected to make decisions of as high a quality as the groups in the same information treatment cells. These groups were also expected to make decisions of a higher quality than groups in the face-to-face meeting exclusively and biased information distribution treatment cell. Therefore two hypotheses with respect to decision quality were postulated as

Hypothesis 4: Groups in the GSS augmented face-to-face meeting environment and biased information distribution treatment cell will make decisions of the same quality as groups assigned to the same information treatment cells.

$$4a \begin{array}{lllll} H_0 & : & \mu_C & = & \mu_B \\ H_a & : & \mu_C & \neq & \mu_B \end{array} \qquad 4b \begin{array}{lllll} H_0 & : & \mu_C & = & \mu_D \\ H_a & : & \mu_C & \neq & \mu_D \end{array}$$

Where

μ_B = Mean of the quality of decisions made by groups in the face-to-face exclusively meeting environment and same information distribution treatment cell.

μ_C = Mean of the quality of decisions made by groups in the GSS augmented face-to-face meeting environment and biased information distribution treatment cell.

μ_D = Mean of the quality of decisions made by groups in the GSS augmented face-to-face meeting environment and same information distribution treatment cell.

and,

Hypothesis 5: Groups in the GSS augmented face-to-face meeting environment treatment cell will make decisions of a higher quality than groups in the face-to-face meeting exclusively and biased information distribution treatment cell.

$$5: \quad \begin{matrix} H_0 : \mu_A - \mu_C = 0 \\ H_a : \mu_A - \mu_C < 0 \end{matrix}$$

Where

μ_A = Mean of the quality of decisions made by groups in the face-to-face exclusively meeting environment and biased information distribution treatment cell.

μ_C = Mean of the quality of decisions made by groups in the GSS augmented face-to-face meeting environment and biased information distribution treatment cell.

ANALYSIS AND RESULTS

Table 3 shows descriptive statistics for the three dependent variables that were recorded in each treatment cell. The dependent variables were the number of facts assembled, time to reach consensus on ranking of the candidates, and quality of candidate ranking based on a scoring table. See Table 2.

Table 3: Descriptive statistics

		Number of Facts (Count)		Time to Decision (Minutes)		Decision Quality (Scale 1 to 6)	
Treatment Cell[1]	n[2]	Mean	Std Dev	Mean	Std Dev	Mean	Std Dev
A	12	28.00	1.65	19.83	3.41	3.92	1.56
B	12	30.25	2.30	21.00	3.13	5.17	0.83
C	12	31.83	0.72	15.00	3.05	5.33	0.77
D	12	32.58	0.67	16.08	2.94	5.42	0.90
F-value		21.94		10.18		5.19	
P-value		0.000		0.00		0.037	

Notes
1. Treatment cells, see Table 1.
2. n = number of groups in a treatment cell

The last two rows in Table 3 show the F and p-values for the cell means model $Y_{ij} = \mu_i + \varepsilon_{ij}$. Where Y_{ij} is the value of the dependent measure for group *j* in treatment cell i. The dependent measures or response variables were the number of facts, time to decision, and decision quality. The F statistic numbers are tests of the hypothesis that all mean cells are equal. The null hypothesis is rejected for all three dependent measures. Information distribution and meeting environment affected the three response variables. Multiple comparisons of cell means were computed using the Tukey method (Tukey, 1953) to test the above hypotheses. The Tukey method computes the set of all pairwise comparisons of factor level means. When cell means are not equal the confidence interval range for the difference between any two cell means is more conservative than the range produced when the difference between the same two cells means is computed in isolation (Neter, Wasserman, and Kutner, 1990).

Table 4 shows simultaneous confidence intervals for linear combinations of cell means of the number of facts assembled by groups.

The point estimate for the difference between the mean of the number of facts assembled by groups in treatment cell B and the mean of the number of facts assembled by groups in treatment cell C is -1.58 and the 95% confidence interval range is -3.22 to 0.05. Since this range includes the number zero, the

difference between the cell means is not statistically significant. Therefore, the hypothesis that groups in treatment cell C assembled as many facts as groups in treatment cell B is accepted. A similar conclusion is reached for hypothesis 1b. The point estimate for the difference between the means of the number of facts assembled by groups in treatment cells C and D is -0.75. The 95% confidence interval range (-2.38 to 0.88) includes zero hence the two cell means are not statistically different. Overall hypothesis 1 was supported. Groups that were given biased information but shared the information using an asynchronous GSS before discussing the problem in a face-to-face meeting assembled as many facts as the control groups that were given the same unbiased information.

Table 4: Simultaneous confidence intervals for specified linear combinations of cell means of the number of facts assembled.

		95% Confidence interval range[2]		
Interval[1]	Estimate	Lower Bound	Upper Bound	
A - B	-2.25	-3.88	-0.62	***
A - C	-3.83	-5.47	-2.20	***
A - D	-4.58	-6.22	-2.95	***
B - C	-1.58	-3.22	0.05	
B - D	-2.33	-3.97	-0.7	***
C - D	-0.75	-2.38	0.88	

*** interval excludes 0 indicating significant difference.

Notes

1. The difference between cell means, e.g. A – B = mean for cell A minus mean for cell B
2. Computed using the Tukey method

Hypothesis 2 was to test if groups in treatment cell C pooled more facts than groups in treatment cell A. The point estimator of the difference of the mean of the number of facts pooled by groups in treatment cell A and the mean of the number of facts pooled by groups in treatment cell C is -3.93 and the 95% confidence interval range is -5.47 to -2.20. This means that 95% of the time the difference between the cell means is never zero; hence, the difference between the two means is statistically significant. The null hypothesis is rejected. Groups in the GSS augmented face-to-face meeting environment and biased information distribution cell pooled more facts than groups in the face-to-face meeting exclusively environment and biased information distribution cell. Hypothesis 2 was therefore supported.

Table 5 shows the 95% simultaneous confidence intervals for the mean time it took groups to reach a consensus on the ranking of the three candidates. Hypothesis 3 was to test if groups in the GSS augmented face-to-face meeting environment treatment, that is, treatment cells C and D would take less time to reach a decision than groups in the face-to-face meeting exclusively environment treatment, that is, treatment cells A and B. Comparing the mean time to decision for groups in treatment cell A with groups in treatment cell C, the point estimate is 4.83 and the 95% confidence interval range is 1.42 to 8.25. At a 95% level of confidence this range is always positive, which means groups in the face-to-face meeting exclusively environment and biased information distribution treatment cell took significantly more time to reach a consensus ranking of the candidates than groups in the same information distribution treatment but deciding in a GSS augmented face-to-face meeting environment. The null alternative, that the two means are equal, is rejected. The null hypothesis is also rejected for hypothesis 3b. The point estimate of the difference between the mean times to decision for treatment cells B and D is 4.92 and the 95% confidence interval range is 1.5 to 8.33. Since this range does not include zero, the difference between the cell means is significant. Groups in the same information distribution treatment who shared information and made a decision in a face-to-face meeting exclusively environment took more time to reach a consensus than groups in the same information distribution treatment who shared information and made a decision in a GSS augmented face-to-face meeting environment.

Decision quality was tested by comparing the performance of groups assigned to treatment cell C to groups assigned to the other three treatment cells. Table 6 shows simultaneous confidence intervals for cell means of the decision quality. Hypothesis 4 tested if the quality of decisions made by groups in treatment cell C were of equal value to the quality of decisions made by groups in treatment cells B and D. The point estimate of the difference between means of decision quality for treatment cells B and C is -1.67 and

the 95% confidence interval range is -1.33 to 0.99. Since this range includes zero, the alternative hypothesis, that the two cell means are different is rejected. Groups in the GSS augmented face-to-face meeting environment and biased information distribution treatment cell made decisions that were of the same quality as decisions made by groups in the face-to-face meeting exclusively environment and same information distribution treatment cell.

Table 5: Simultaneous confidence intervals for specified linear combinations of cell means of the time to decision

		95% Confidence interval range[2]		
Interval[1]	Estimate	Lower Bound	Upper Bound	
A - B	-1.17	-4.58	2.25	
A - C	4.83	1.42	8.25	***
A - D	3.75	0.33	7.17	***
B - C	6.0	2.38	9.42	***
B - D	4.92	1.5	8.33	***
C - D	-1.08	-4.5	2.33	

*** excludes 0 indicating significant difference.
Notes
1 The difference between cell means, e.g., A – B = mean for cell A minus mean for cell B
2. Computed using the Tukey method

The point estimate of difference between cell means of decision quality for treatment cells C and D is -0.08 and the 95% confidence interval range is -4.5 to 2.33. Since, this range includes zero, the difference between the cell means is not significant. Therefore, the alternative for hypothesis 4b is rejected. Groups in the GSS augmented face-to-face meeting environment treatment cells made decisions of the same quality. Overall hypothesis 4 is supported. Groups in the GSS augmented face-to-face meeting environment treatment cell made decisions that were as good as decisions made by groups in the same information distribution treatment cells.

Hypothesis 5 was to test if decisions made by groups in treatment cells A and C were of the same quality. The point estimate for the difference between the means of decision quality for groups in treatment cells A and C is -1.42 and the 95% confidence interval range is -2.58 to -0.25. At a 95% level of confidence the mean for the quality of decisions made by groups in treatment cell A is always less than the mean for the quality of decisions by groups in treatment cell C. The null hypothesis is rejected. Groups in the GSS augmented face-to-face meeting environment and biased information distribution treatment cell made decision of a higher quality than groups in the face-to-face exclusively meeting environment and biased information distribution treatment cell.

Table 6: Simultaneous confidence intervals for specified linear combinations of cell means of decision quality

		95% Confidence interval range[2]		
Interval[1]	Estimate	Lower Bound	Upper Bound	
A - B	-1.25	-2.41	-0.07	***
A - C	-1.42	-2.58	-0.25	***
A - D	-1.50	-2.66	-0.34	***
B - C	-1.67	-1.33	0.99	
B - D	-0.25	-1.41	0.91	
C - D	-0.08	-1.25	1.08	

*** excludes 0 indicating significant difference.
Notes
1 The difference between cell means, e.g. A – B = mean for cell A minus mean for cell B
2. Computed using the Tukey method

DISCUSSION

The purpose of this research was to test a group support configuration methodology rather than to find an explanation for some of the inconsistent results of laboratory studies on group support systems. We postulate that supporting the whole decision-making process with one type of decision support system may be the reason why there are no conclusive results attesting to the superiority of GSS over the traditional face-to-face meeting. Since this research tries to explain the inconsistencies of a stream of research, its findings can only be consolidated and generalized by a stream of research of similar design.

The results of this research show that support given to a group affects how well the group answers the question, "What are the facts?" Among groups where individual group members were given less than full sets of biased information, groups that shared information using the asynchronous GSS and discussed in a face-to-face meeting pooled more information than groups that shared

information and discussed in a face-to-face meeting. Both groups used an implementation of the NGT to share information. This result has been documented in other research studies, for example Dennis (1996). However, the significant difference of information pools between groups assigned full-unbiased information sets and meeting in a face-to-face environment and groups assigned full-unbiased information sets and sharing information using an asynchronous GSS has no obvious intuitive explanation. A possible reason is that face-to-face groups chose not to bring up for discussion some facts that they thought were not important. Since everybody had the same information, nobody noticed that the information was missing. In this research we tested the efficiency of using an asynchronous GSS for answering the "what are the facts?" question, rather than, a face-to-face meeting environment. A variation of the test would be to compare an asynchronous GSS with a synchronous GSS, or all three major options at the same time.

Time to decision and decision quality were surrogate measures of group information sharing effectiveness. The difference between groups that deliberated on the problem in face-to-face meetings exclusively and groups that first shared information using the asynchronous GSS and then discussed the problem in a face-to-face meeting was that the latter groups had more time to reflect on shared information than the former groups. Both sets of groups did not however mix information sharing and discussion. Groups that shared information in a face-to-face meeting environment took longer to reach a consensus than groups that shared information using an asynchronous GSS. This finding points to the significance of reflecting on shared information. Groups that shared information using an asynchronous GSS had time to reflect on the shared information and had therefore a deeper understanding of the facts than the other groups that had just shared the information. We had expected no time to decision difference among groups that were assigned to the full-unbiased information distribution treatment. The significant time to decision difference between groups that shared information in a face-to-face environment and groups that shared information using an asynchronous GSS is another finding that has no obvious intuitive explanation. Both sets of groups did not gain new information from sharing and had the same information for the same length of time prior to the face-to-face discussion meeting.

Decision quality was a surrogate measure of the effectiveness of the group configuration methodology proposed in this research. Groups that were assigned less than full sets of biased information and using different support systems for different phases of the decision-making process made decisions of equal value to groups that were assigned full-unbiased information sets.

CONCLUSIONS AND FUTURE RESEARCH

Findings of this research show that the separation of group task activities and using different methods and means to support them has a significant effect on group performance. Three basic ways of supporting group task activities include: use of asynchronous GSS, use of synchronous GSS (Decision Room Systems), and the traditional face-to-face meeting using pen and paper. The group decision-making process can on the other hand be broken into three distinct activities gathering the facts (group information sharing), organizing and evaluating the gathered information, and drawing conclusions from the examination of the facts (Bales 1950). Any one of the above mentioned methods could be used to support any of these activities. This research focused on the use of a Web-based asynchronous system to support the gathering of facts and the traditional face-to-face meeting to support the evaluation of the gathered facts. Future research will be directed towards other support method/group task activity combinations. Findings of this research are an important addition to the stream of research focused on the business value of telecommuting.

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